R&D and Innovation for PG&E Gas Operations

François Rongere

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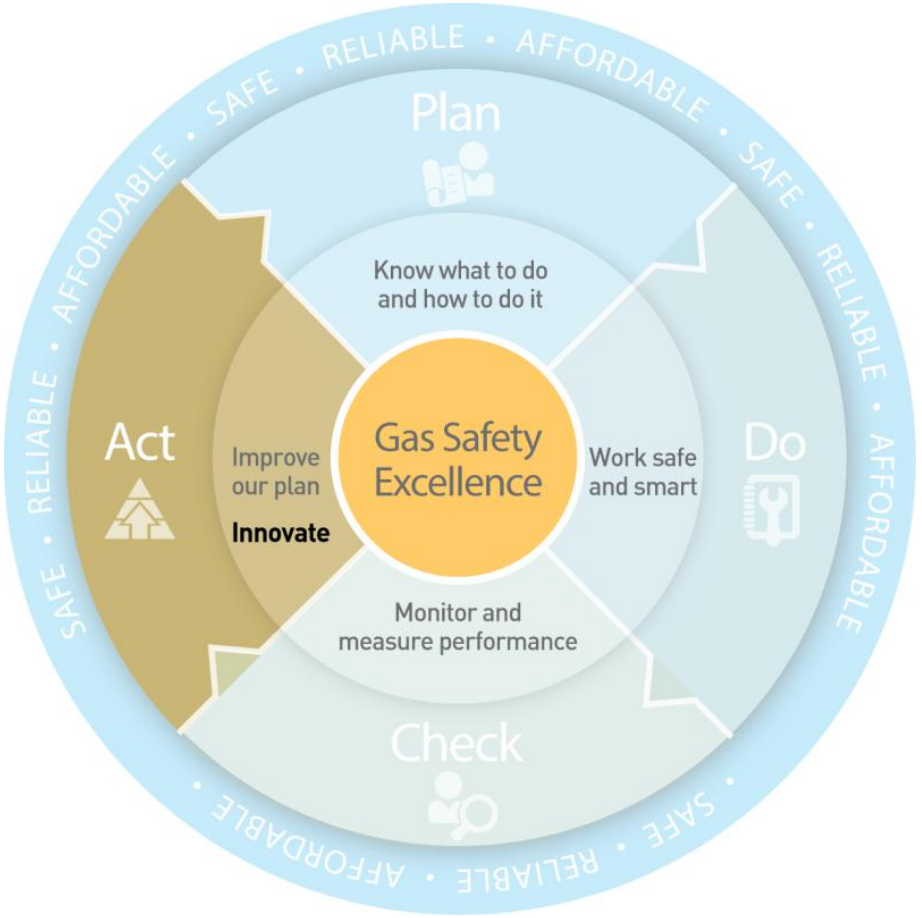
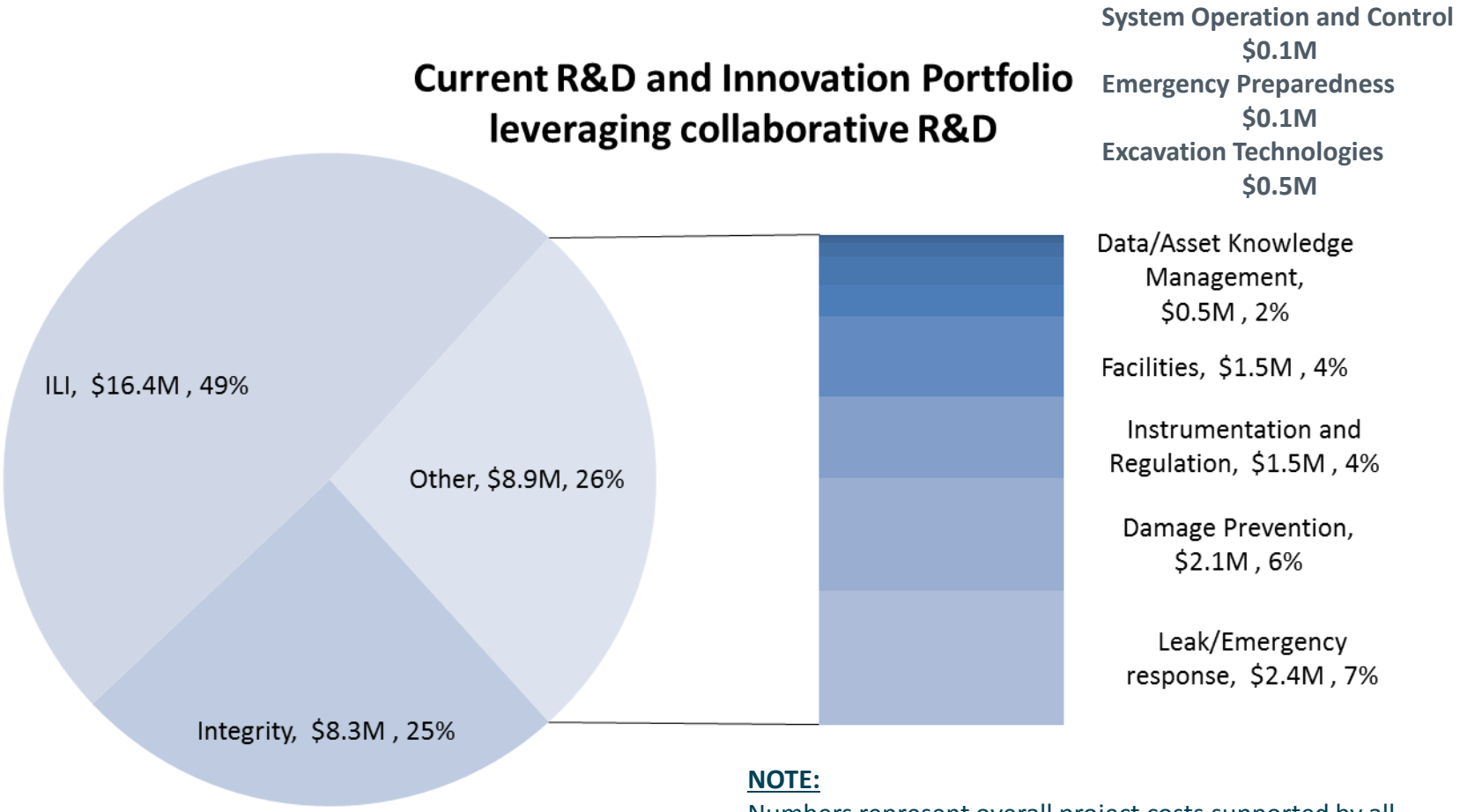
R&D and Innovation part of Gas Safety Excellence

- Innovation is key to improve Gas Safety at an affordable cost.
- PG&E has introduced a systematic risk-based management of its assets following the continuous improvement Plan, Do, Check, Act sequence based on the ISO 55001 standard.
- R&D and Innovation is used to improve tools and methods and is part of the Act phase of the Gas Safety Excellence sequence.



R&D and Innovation Portfolio

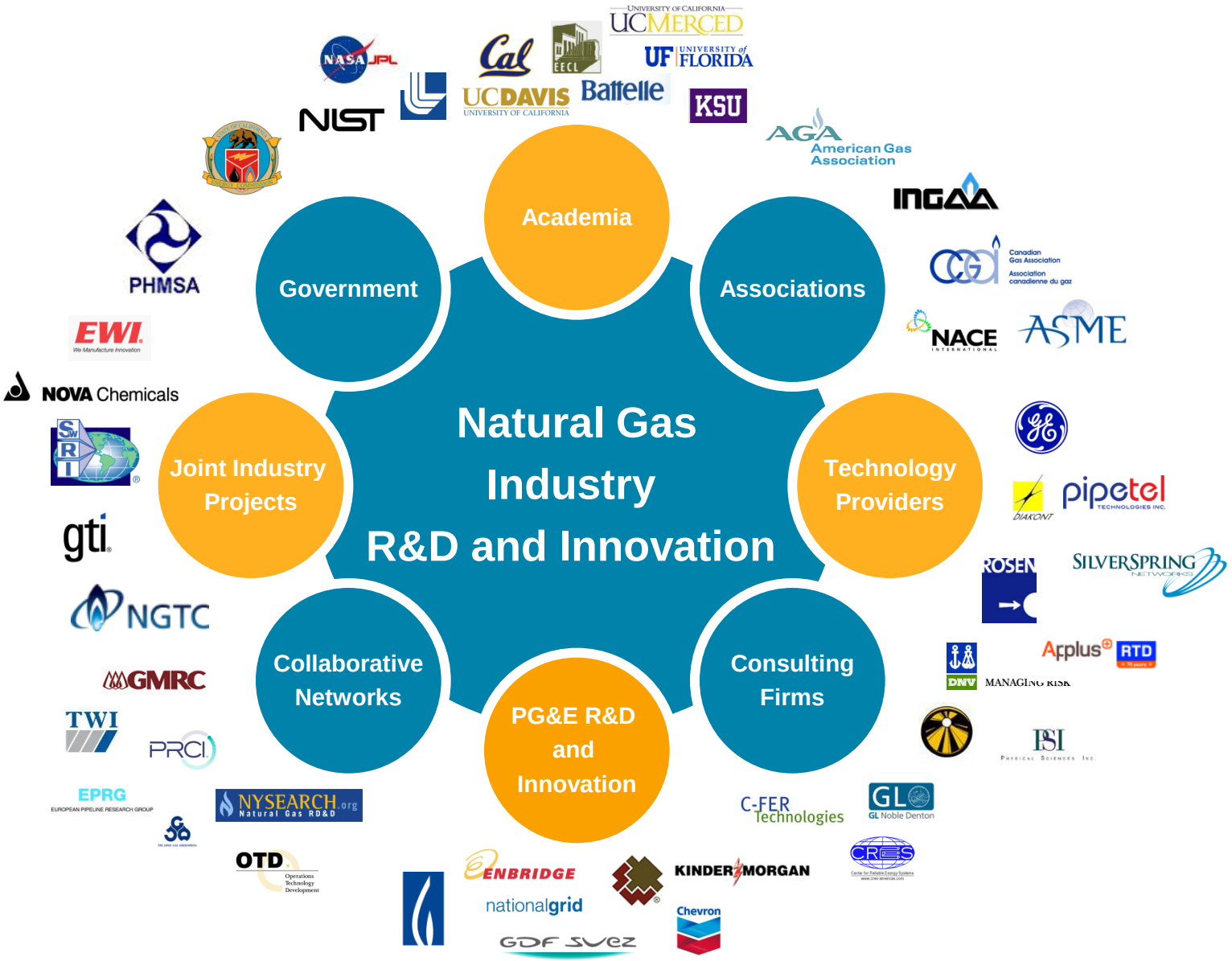
- **92 active projects, 33 in evaluation (as of May 31st, 2014)**



TOTAL: $34M for $4.9M PG&E funding
Leverage Factor: 7

NOTE:
Numbers represent overall project costs supported by all funders, PG&E's share is about 7 times less.
Numbers are not Annual Budget. Projects may be longer or shorter than a year.

R&D and Innovation Connection



Success Stories

Explorer Robotic Tools

Explorer 20/26 with high resolution cameras, Magnetic Flux Leakage sensor, and Mechanical Damage Sensor

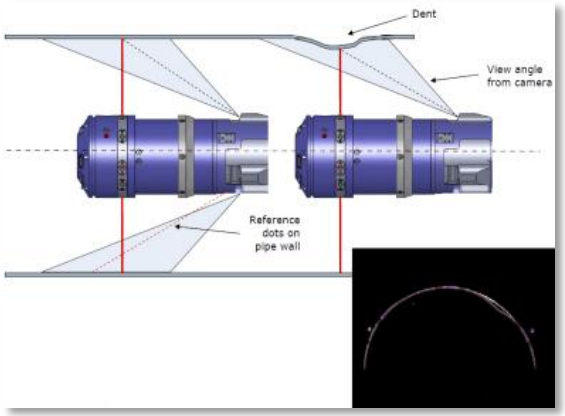
- Non-tethered, battery-powered in-line inspection robotic tools for unpiggable transmission pipelines.
- Key Features:
  - Launch and receive through pressure control fitting via hot tap (traditional pig launcher and receiver not required)
  - Navigates through “unpiggable” features:
    - Mitered and < 1.5D radius bends
    - Plug valves
    - Low pressure and flow conditions
  - Performs NDE (Non-Destructive Evaluation) and visual inspection (2 high resolution cameras) for metal loss, cracks, and mechanical damage.

Explorer Robotic Tools

Platform	Status
Explorer 6/8	- Remote Field Eddy Current (RFEC) version commercially available. - Magnetic Flux Leakage (MFL) versions in development, expected commercial availability expected 4Q 2015.
Explorer 10/14	- MFL version commercially available. - Deployed twice at PG&E.
Explorer 16/18	- Currently in development (PG&E not funding due low mileage in this diameter range). - Expected commercial availability expected 2Q 2015
Explorer 20/26	- MFL version commercially available. - Deployed once at PG&E.
Explorer 30/36	- PG&E hosted the first demonstration of this largest platform in July 2013. Currently awaiting final field test on the East Coast. - Commercial availability expected 4Q 2014.

Explorer Sensors & Technologies

Mechanical Damage Sensor



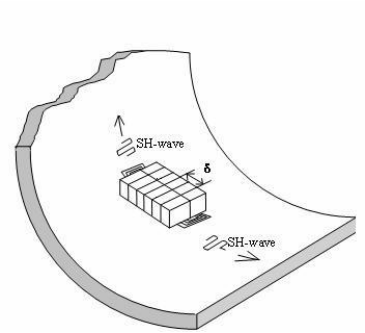
Laser-based sensor detects and measures mechanical damage and ovality

In-Line Charging Tool

Charges batteries of Explorer tools through a hot tap to extend range of inspection.

Rescue Tool

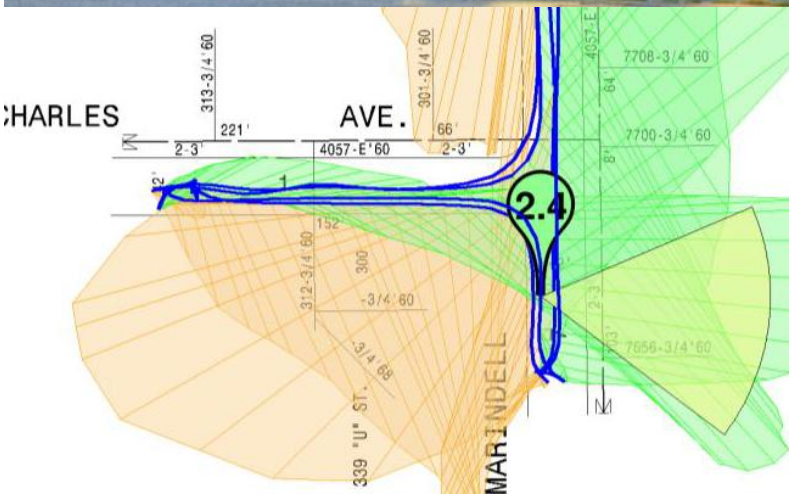
Crack Sensor



Combination of Electromagnetic Acoustic Transducer (EMAT) and Transverse MFL to detect cracks *(in development)*

Pipeline Cleaning Tool

High Sensitivity Methane Detector



- Cavity Ring Down Spectroscopy (CRDS) detects methane concentrations as low as 1ppb.
- Allows a more effective sweep of an area with a vehicle to identify possible leaks.
- Data are transmitted immediately and can be viewed remotely in real time.
- Offers many opportunities to improve leak detection and repair process.

2012 2014

Design | Develop | Test | Deploy

Light Weight Methane Detector to Rapidly Locate Leaks

Prototype of Methane Detector by JPL (March 2013)

- Jet Propulsion Laboratory of NASA in Pasadena has developed a miniaturized methane detector to locate methane sources on Mars
- Precision of 10 ppb with an open path of 20 cm by using 3.3 µm absorption band.
- Allows to go from Picarro methane indication to leak by tracking the plume.
- Can be mounted on a UAV for rough terrain pipeline survey
- Partnership with PRCI and JPL to complete development and adaptation to our needs

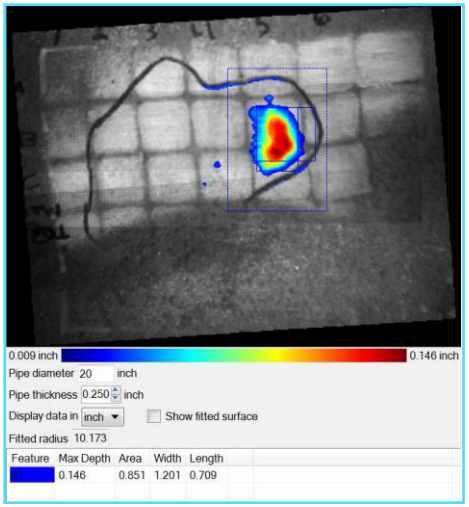
2013 2015

Design | Develop | Test | Deploy

3D Toolbox: 3D Structured Light Measurement System

SEIKOWAVE

3D TOOLBOX
point.click.done.



- First developed for the dental industry, as a spin-off from University of Kentucky, the 3D Toolbox was detected by PRCI through the NASA Tecfusion program.
- Used like a digital camera, 3D Toolbox captures 3D images of pipe surfaces and provides measurements and analyses of the surface condition.
- PG&E verified the tool performance through a series of lab and field tests and is in the final stages of its deployment.

2012 2014

Design | Develop | Test | Deploy

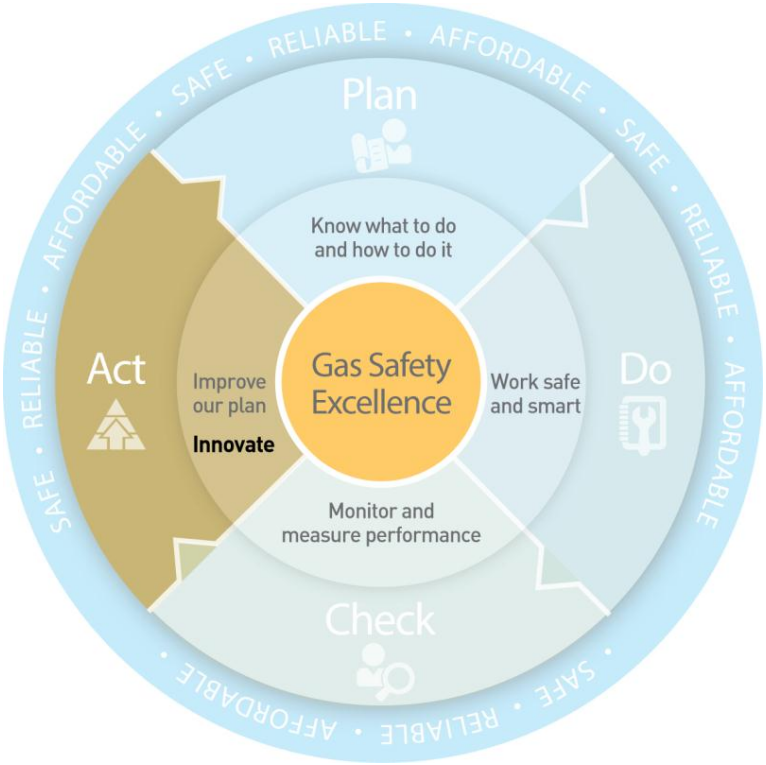
GPS-based Damage Prevention

- Supplements 811 calls to provide additional protection
- Uses GPS location of construction equipment and movement patterns
- Sends alerts to field operators, and utility control room when equipment digs close to underground assets
- Built upon development made by GTI with Virginia Utility Protection Services
- Solution expected to be cheaper and more effective than ultrasonic and fiber optic detection systems

2013 2015

Design | Develop | Test | Deploy

Thank you!



François Xavier Rongere
PG&E Gas Operations
R&D and Innovation
Tel: (925) 244-3070
Cel: (415) 517-0946
E-mail: fxrg@pge.com